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(56) Documents cited GB 885144 GB 771290 GB 697660 GB 683085 GB 650555 GB 497871
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(54) Sintered Alloys

(57) 10 to 85 wt.% of bronze or brass powder is mixed with 90 to 15 wt.% of iron powder. The mixture is compacted and then sintered at a temperature of 700 to 1000°C in a reducing or nonoxidizing atmosphere, which may contain zinc vapour. The sintered alloy may contain a solid lubricant or be impregnated with liquid lubricant so that it can be used as a bearing metal. The particles of iron powder are covered by a copper-rich alloy, resulting in enhanced mechanical strength.

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FIG.2

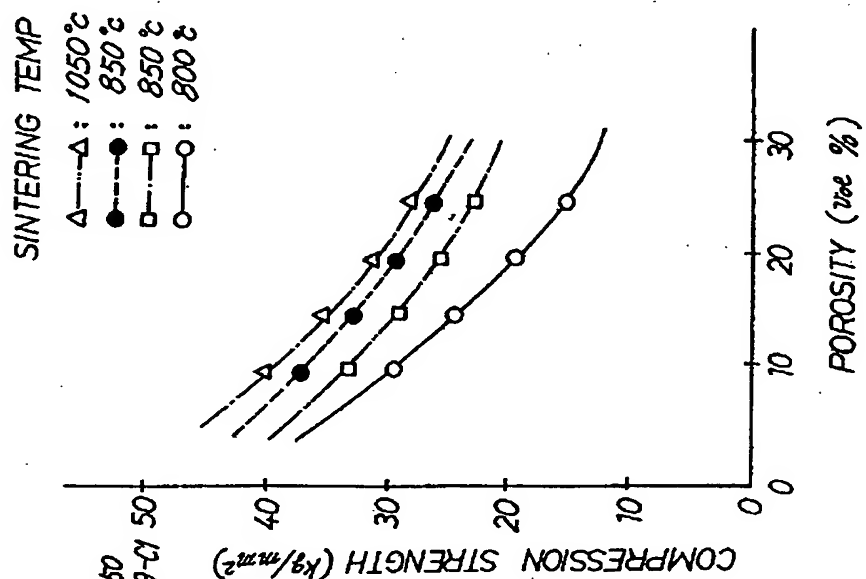

SINTERING TEMP
△—·—△ : 1050°c
●---● : 850°c
□—·—□ : 850°c
○—○ : 800°c
COMPRESSION STRENGTH (kg/mm²)
50
40
30
20
10
0
0
10
20
30
POROSITY (vol %)

FIG.1

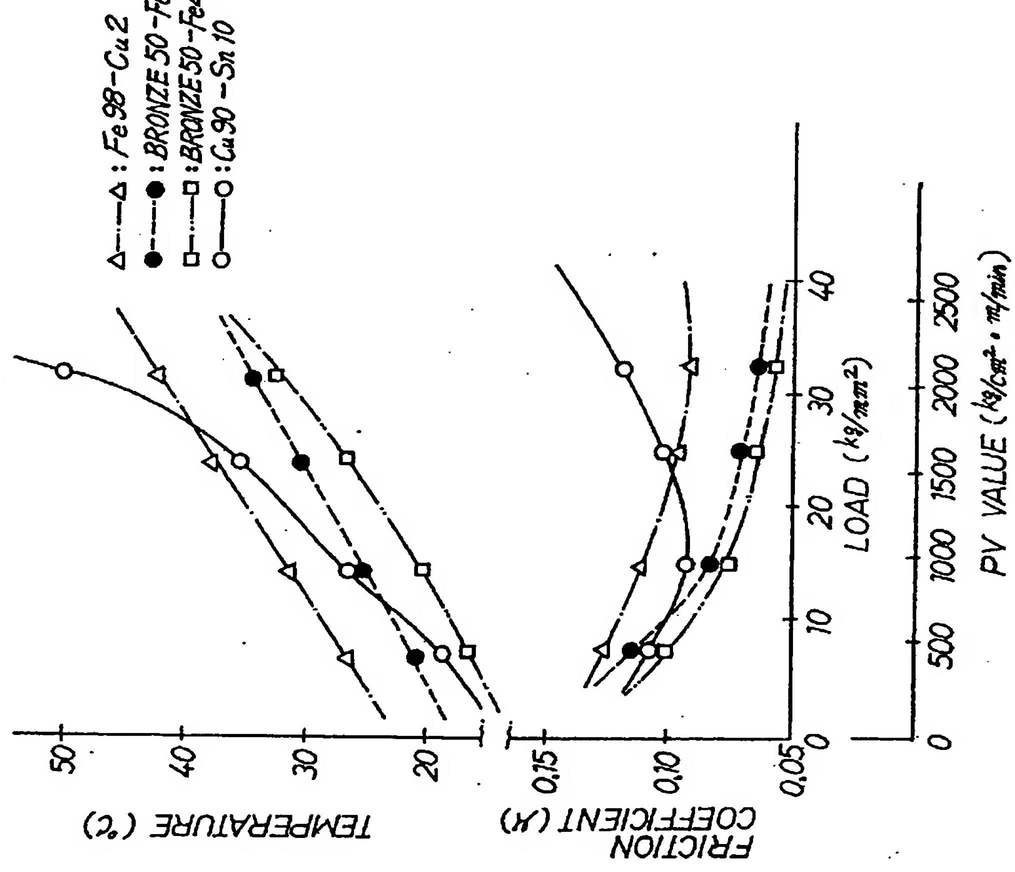

△—·—△ : Fe 98 -Cu 2
●---● : BRONZE 50 -Fe 50
□—·—□ : BRONZE 50 -Fe 49 -C1
○—○ : Cu 90 -Sn 10
TEMPERATURE (°c)
50
40
30
20
FRICTION COEFFICIENT (μ)
0.15
0.10
0.05
0
10
20
30
40
LOAD (kg/mm²)
0
500
1000
1500
2000
2500
PV VALUE (kg/cm² · m/min)

FIG. 3

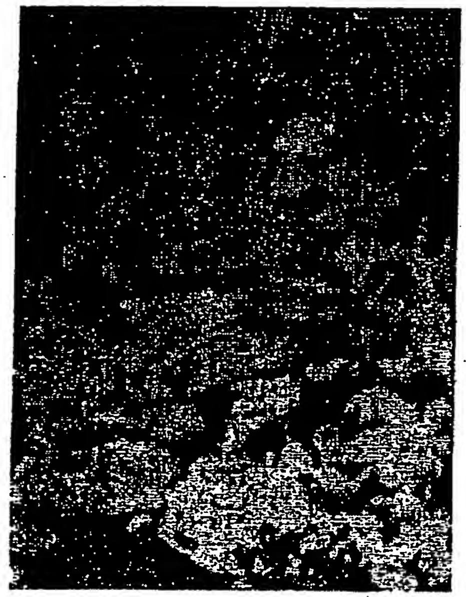


FIG. 4

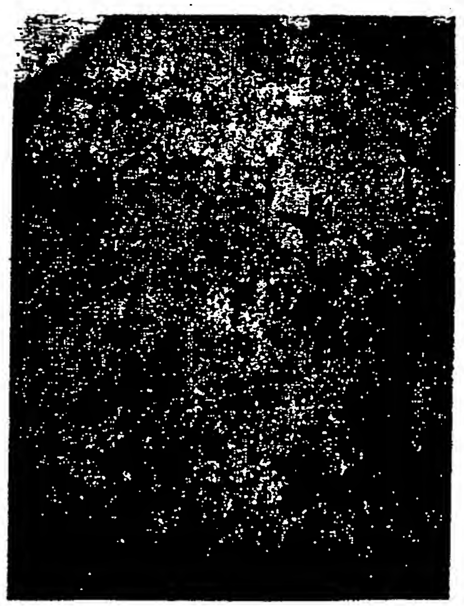


FIG.6

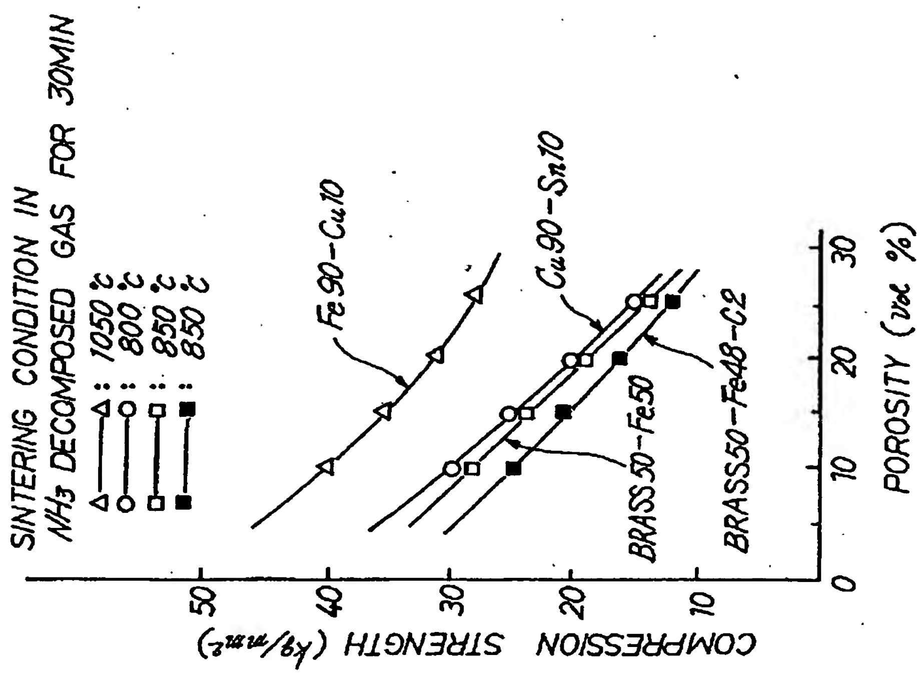

SINTERING CONDITION IN
NH_3 DECOMPOSED GAS FOR 30MIN
1050 °C
800 °C
850 °C
850 °C
Fe90-Cu10
Cu90-Sn10
BRASS50-Fe50
BRASS50-Fe48-C2
COMPRESSION STRENGTH (kg/mm²)
POROSITY (vol %)
50
40
30
20
10
0
10
20
30

FIG.5

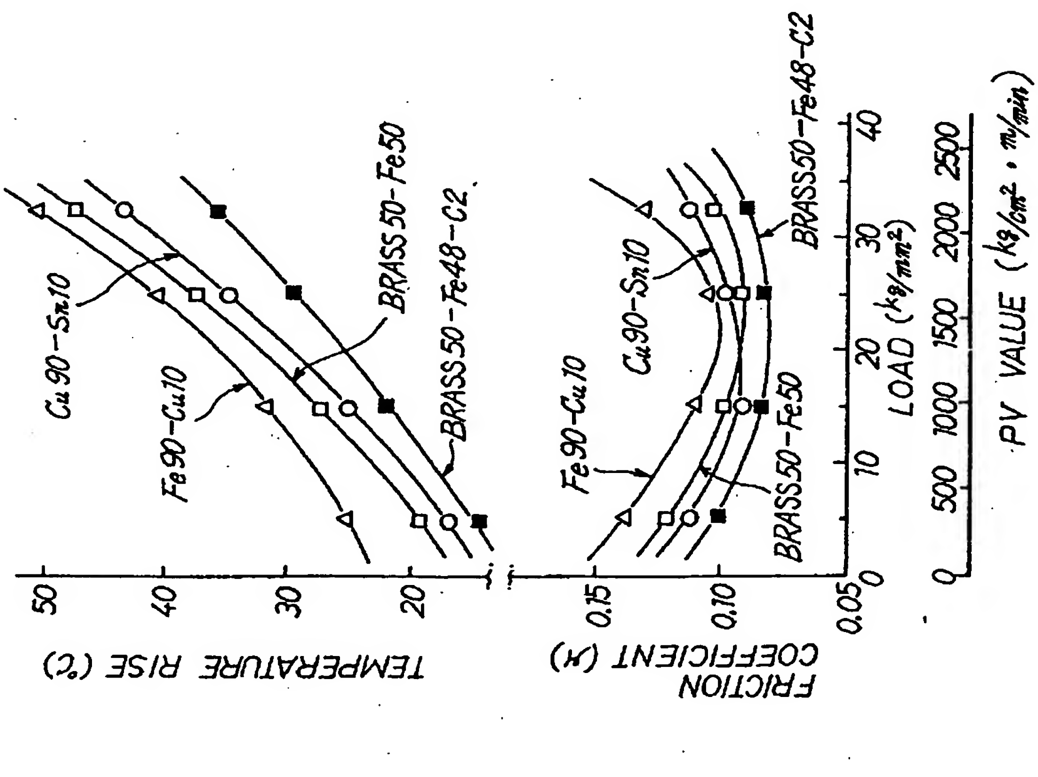

TEMPERATURE RISE (°C)
FRICTION COEFFICIENT (μ)
Cu90-Sn10
Fe90-Cu10
BRASS50-Fe50
BRASS50-Fe48-C2
50
40
30
20
0.15
0.10
0.05
0
10
20
30
40
LOAD (kg/mm²)
0
500
1000
1500
2000
2500
PV VALUE (kg/cm² · m/min)

FIG.8

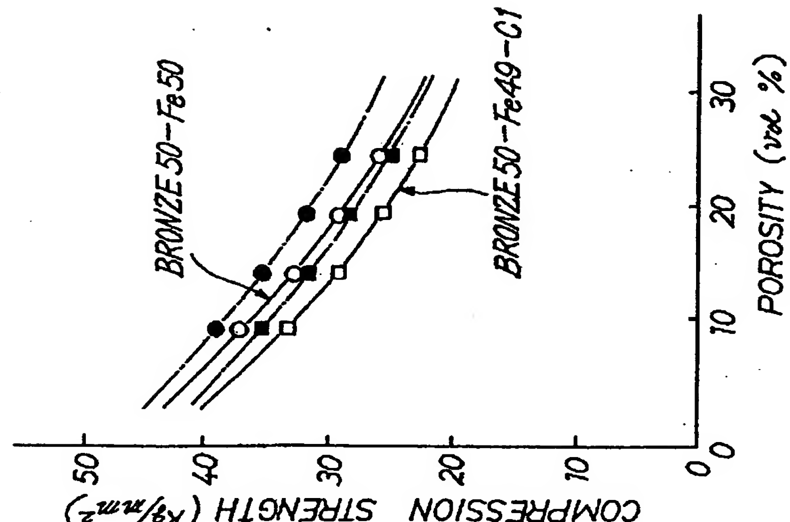

BRONZE 50-Fe 50
BRONZE 50-Fe 49-C1
COMPRESSION STRENGTH (kg/mm²)
POROSITY (vol %)
0
10
20
30
40
50

FIG.7

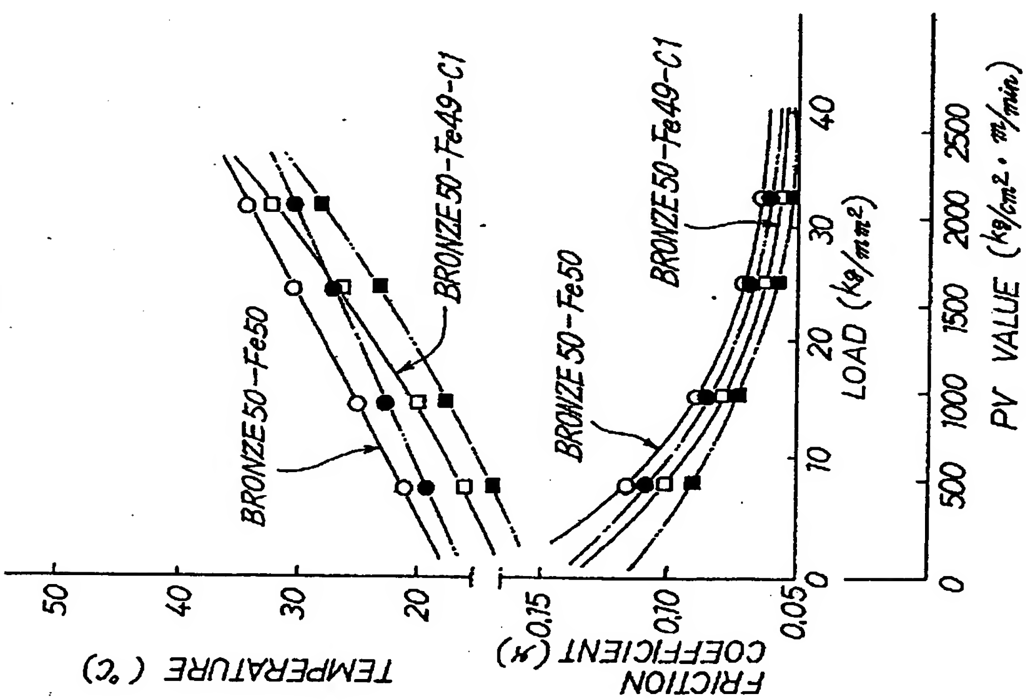

BRONZE 50-Fe 50
BRONZE 50-Fe 49-C1
TEMPERATURE (°C)
FRICTION COEFFICIENT (μ)
LOAD (kg/mm²)
PV VALUE (kg/cm² · m/min)
0.05
0.10
0.15
0
10
20
30
40
50
500
1000
1500
2000
2500

FIG.10

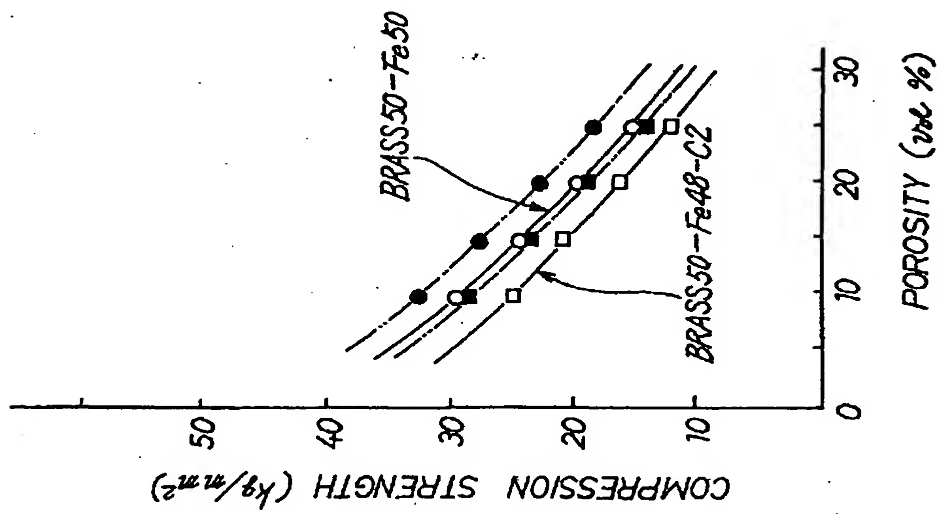
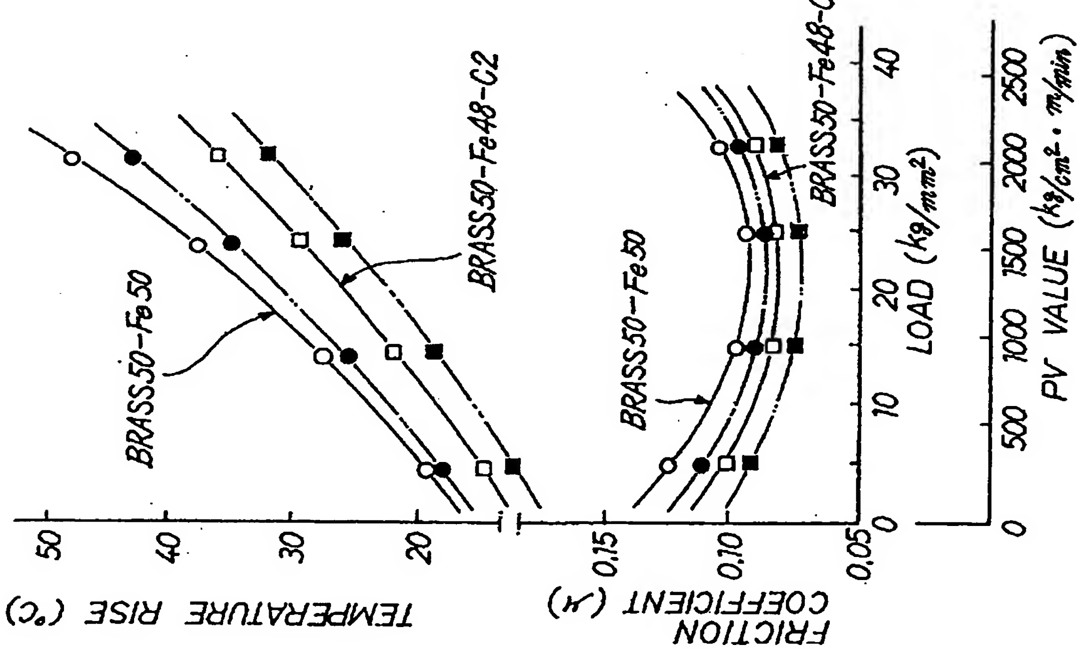

BRASS50-Fe50
BRASS50-Fe48-C2
COMPRESSION STRENGTH (kg/mm²)
POROSITY (vol %)
0
10
20
30
40
50

FIG.9


TEMPERATURE RISE (°C)
FRICTION COEFFICIENT (μ)
BRASS50-Fe50
BRASS50-Fe48-C2
LOAD (kg/mm²)
PV VALUE (kg/cm² · m/min)
0.05
0.10
0.15
0
10
20
30
40
50
500
1000
1500
2000
2500

SPECIFICATION
Sintered Alloys

Various types of sintered alloys utilized as bearing metals and in many other applications have been used which can be generally classified into copper-based and iron-based alloys. The former include Cu-Sn, Cu-Sn-C, and Cu-Sn-Pb-C alloys, whereas the latter include Fe-C, Fe-Pb-C, Fe-Cu, and Fe-Cu-C alloys. The sintered Fe-based alloys have higher hardness than the sintered copper-based alloys so that the fitting thereof to steel shafts is not always satisfactory; also their corrosion resistance is poor when compared with the sintered Cu-based alloys. However, their mechanical characteristics are excellent so that they can be used for articles having a small thickness and can be prepared at a relatively low cost. On the other hand, the sintered Cu-based alloys have inferior characteristics.

The sintered alloys utilized as bearing metals are desired to have good fitting to steel shafts, high corrosion resistance, and high mechanical strength. However, these characteristics conflict with each other and sintered alloys satisfying all of these characteristics are not yet available despite various researches. For this reason, the sintered Cu-based alloys have generally been used as oil impregnated bearing metals, while the sintered Fe-based alloys have generally been used as machine parts.

What are required are sintered alloys having good fitting to shafts, high corrosion resistance, and mechanical strength. It would also be desirable to provide a method of manufacturing sintered alloys which can decrease wear of metal moulds utilized to compact the alloy powders. The sintered alloys should ideally be suitable for manufacturing bearing metals and various machine parts.

According to one aspect of this invention there is provided a sintered alloy comprising a mixture of 10 to 85% by weight of a powder containing more than 50% by weight of copper and a metal selected from the group consisting of zinc and tin; and 15 to 90% by weight of an iron powder, the mixture being compacted and then sintered so as to coat the iron particles with a copper rich alloy.

According to another aspect of this invention there is provided a method of manufacturing a sintered alloy characterised by the steps of mixing copper rich alloy powders containing more than 50% by weight of copper and a metal selected from the group consisting of zinc and tin with iron powders at a weight ratio of 10—85% to 15—90%, compacting a resulting mixture and then sintering a compacted body.

The copper rich alloy is preferably bronze or brass and the sintering step is preferably effected in a reducing or nonoxidizing atmosphere. Zinc vapour may be added to the atmosphere. Preferably the sintered alloy incorporates a solid lubricant or is impregnated with liquid lubricant. The sintered alloy is especially suitable for manufacturing bearings or other machine parts.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a graph showing the relationship between, on the one hand, temperature and friction coefficient and, on the other hand, load and PV value (defined below) for sintered alloys according to the invention and conventional sintered alloys;

Figure 2 is a graph showing the mechanical characteristics of the same alloys as for Figure 1;

Figure 3 is a photomicrograph showing one example of a sintered alloy according to the invention;

Figure 4 is a photomicrograph showing a conventional sintered alloy having a similar composition;

Figure 5 is a graph similar to that of Figure 1, comparing bearing characteristics of sintered alloys according to the invention and of conventional sintered alloys;

Figure 6 is a graph showing the mechanical characteristics of the same sintered alloys as for Figure 5;

Figure 7 is a graph similar to Figure 1, for sintered alloys of bronze and iron according to the invention treated and not treated with zinc-vapour-containing atmosphere;

Figure 8 is a graph showing the relationship between the porosity and compression strength (defined below) of bronze type sintered alloys according to the invention treated and not treated with zinc-vapour-containing atmosphere;

Figure 9 is a graph similar to Figure 1, for brass type sintered alloys of this invention treated and not treated with zinc-vapour-containing atmosphere; and

Figure 10 is a graph showing the relationship between the porosity and the compression strength of the alloys of Figure 10.

As is well known in metallurgical art, among copper alloys are included bronze type and brass type alloys. This invention is applicable to the both types of the copper alloys. We have found that the performance at the time of sintering greatly differs for a case in which copper, tin, and zinc are independently incorporated and for a case wherein they are incorporated in the form of bronze or brass.

Generally, bronze has a composition consisting of 79—90% by weight of Cu, 2—11% by weight of Sn, and 1—12% by weight of Zn. (Hereinafter all percent are weight percent except as otherwise specified). In some cases a certain amount of lead may be added. Although the characteristics of bronze varies substantially when the proportion of the components varies in the ranges just specified, the melting point of bronze is lower than that of copper. When powders of iron, copper, and zinc are mixed together, compacted, and then sintered, due to the fact that tin, copper, and iron have melting points of 230°C, 1083°C, and 1539°C respectively, segregation of tin occurs, thus causing so-called "tin sweating". As a

consequence, a hard phase containing a large quantity of tin and rich in δ phase would be resulted. Such alloys lack sufficient fitting property necessary for bearing metals.

Where a powder of bronze, i.e. an alloy of copper and tin, is used together with an iron powder, the mixture is sintered at a temperature considerably lower than the sintering temperature of 1100°C of the Fe-based sintered metals. Moreover, at the time of sintering, a portion of the bronze forms a eutectic alloy with iron. Such a eutectic alloy covers the surface of the iron particles so that, even when a substantial amount of iron powder is incorporated, the resulting sintered alloy manifests a colour resembling that of a simple sintered copper-based alloy, thus resulting in a sintered alloy having a uniform composition and free from any segregation, which has previously been inevitable in sintered Fe-Cu based alloys. The sintered alloy having a uniform composition, free from any segregation and in which the iron particles are coated with a bronze-iron alloy, has a sufficiently high corrosion resistance. Thus, the sintered alloy in which the iron particles are coated with a bronze type alloy has a mechanical strength equal to or larger than that of the conventional sintered Fe-based alloy. Moreover, the bronze-iron alloy coating results in a favourable fitting characteristic with respect to a steel shaft.

Brass generally contains 59—88% of copper, less than 1% of one or more of Pb, Sn, Al, and Fe, and the balance zinc (usually from 10 to 39%). Although the characteristics of the sintered alloy varies when the components vary in the ranges just specified, the melting point of brass is substantially lower than that of copper alone. Where powders of iron, copper, and zinc are mixed together, since the melting point of zinc is relatively low, i.e. approx. 420°C, whereas those of copper and iron are high, i.e. 1083°C and 1539°C respectively, mere admixing, compacting, and sintering of the three metals result in segregation of zinc. Accordingly, not only when zinc alone is incorporated but also (to a lesser extent) when it is incorporated in the form of brass the zinc component vaporises so that the advantageous characteristics to be described later may not be obtained.

Where an alloy powder of brass consisting of copper and zinc is added to an iron powder as the major component and 2 to 7% of copper powder or 3 to 20% of bronze powder is added to the brass and iron mixture, it is possible to sinter the mixture at the sintering temperature of 1100°C of sintered Fe-based alloys. Moreover, at the time of sintering, a portion of the brass and iron form an eutectic alloy which covers the iron particles. Accordingly, in spite of the fact that a substantial quantity of iron is used it is again possible to obtain sintered alloys having a colour resembling the colour of brass type sintered alloys and having a uniform composition and moreover free from segregation, which has previously been unavoidable in sintered Fe-Cu alloys.

Furthermore, it is possible to prevent loss of zinc by evaporation. The sintered alloys have sufficiently high corrosion resistance and excellent mechanical strength, comparable with that of sintered Fe-based alloys, as well as good fitting property to steel shafts.

If the proportion of the bronze powder to the iron powder were less than 10% the characteristics of the resulting sintered alloys would not substantially differ from those of simple sintered Fe-based alloys and the advantageous bronze-iron eutectic alloy would not be formed as desired. On the other hand, if bronze powder in excess of 85% were used, particles of iron would not be efficiently covered by bronze, with the result that the mechanical strength of the sintered alloys would decrease to that of the sintered Cu-based alloys. Especially, if the bronze powder contains an excessive amount of tin, a hard phase containing so-called hard spots appears, thus failing to accomplish the object of this invention.

The sintering temperature should be varied as a function of the amount of the bronze powder, which varies in the range specified above. For example, where the bronze powder amounts to 10% (i.e. iron powder 90%) a preferred sintering temperature is about 950°C, whereas where the bronze powder amounts to 85% (iron powder 15%) a preferred sintering temperature is about 800°C. of course, the sintering temperature for bronze powder of a proportion between 10 and 85% is varied correspondingly. Where graphite or other solid lubricant is added, preferably in an amount of less than 3% by weight, the characteristics of the sintered alloy can be improved.

When a brass powder is substituted for a bronze powder, the percentage of the brass powder may be varied in a range of from 30 to 70% by weight. If the amount of the brass powder is less than 30%, the characteristics of the resulting sintered alloy become close to that of a simple sintered Fe-based alloy, since the eutectic alloy of brass and iron may not be formed to a sufficient extent. On the other hand, if the quantity of brass exceeds 70% the iron particles may not be completely covered by the eutectic alloy of brass and iron, thus decreasing the mechanical strength of the sintered alloy. In order to prevent loss of zinc by evaporation during the sintering of a compacted mixture of iron and brass powders it is advisable to incorporate at least 3 parts of copper or bronze based on 100 parts of the mixture. The upper limits of copper and bronze powders are 7% and 20% respectively, and incorporation of these components beyond these limits is not only uneconomical but also decreases mechanical strength, owing to excessive copper content.

The sintering temperature should be varied as a function of the amount of brass powder, which varies in the range described above. For example, for an amount of the brass powder of 30% (iron powder 70%) a preferred sintering temperature is about 900°C, whereas for an amount of the brass

powder of 70% (iron powder 30%) a preferred sintering temperature is about 820°C. For sintered alloys having compositions between those just mentioned, the sintering temperatures are varied accordingly.

Where a graphite powder in an amount of less than 6 parts (by weight) or a powder of molybdenum or molybdenum disulphide in an amount of less than 3 parts is added to 100 parts of a mixture of iron and brass or bronze the characteristics of the sintered alloy can be improved.

The compacting of a mixture of iron powder and an alloy powder consisting mainly of copper may be done by any one of the well-known compacting methods. By virtue of this invention, such compaction can be performed with a relatively low pressure, yet providing a sufficiently high mechanical strength. In order to improve the mechanical strength of a sintered alloy it is necessary to increase the compacting pressure and the sintering temperature but high compacting pressure not only requires a rigid compacting press but also increases wear of the metal mould. With high pressure compacting, although the mechanical strength is improved, the porosity inherent to the sintered metal is greatly decreased, whereby the oil content of the sintered metal decreases when such sintered metal is impregnated with oil for use as bearings. This also increases the amount of the mixed powder of raw materials required. In contrast, by virtue of this invention this problem can be solved so that even with a relatively low compacting pressure products of high mechanical strength can be obtained.

One of the preferred features of this invention lies in that, when sintering a compacted body in a reducing or nonoxidizing atmosphere, a powder or piece of Zn or ZnO is mounted on the compacted body to be sintered or Zn vapour generated in a separate vessel is introduced into a sintering chamber, thus sintering the body in the Zn-vapour-containing atmosphere, whereby the Zn vapour is absorbed in the structure of the compacted body to form alloys with the components of the sintered body. This also prevents the Zn component contained in an alloy powder consisting mainly of copper from being lost by evaporation during sintering. Moreover, where a brass powder is used as the copper-based alloy powder it is possible to eliminate the use of copper or bronze powder or to decrease the amount thereof to be incorporated. The sintered alloy which has absorbed Zn vapour has a high mechanical strength even at a relatively low density. Compacting of such a relatively low density product can be effected readily and smoothly with low wear of the metal mould. Moreover, as the porosity can be increased, it is possible not only to increase the oil content but also to reduce the quantity of the raw materials required to obtain a product having predetermined dimensions.

The sintering temperature in the case just described is generally less than 1000°C, which is lower than that of the sintered Fe-based or Cu-based alloy described above. The Zn vapour can be prepared from Zn or ZnO, at a temperature of 700°C, and a temperature of 700 to 1000°C is sufficient even when the sintering temperature is adjusted depending upon the amount of incorporation of the bronze or brass powder.

For better understanding of the method of this invention, the following examples are given.

Example 1

A bronze powder of 100—350 mesh, obtained by water atomizing a bronze alloy melt consisting of 81.0—87.0% of Cu, 4.0—6.0% of Sn, 4.0—7.0% of Zn, and the balance iron and other impurities, was mixed with an equal weight of an iron powder of 150—250 mesh. The mixture was compacted into the form of a bearing member having an outer diameter of 10 mm, an inner diameter of 4 mm, and a height of 8 mm, and the bearing member was sintered at a temperature of 850°C in a reducing atmosphere. Figure 3 is a photomicrograph of the sintered alloy at a magnification factor of 400. From Figure 3 it can be noted that the surfaces of the iron particles are uniformly coated with bronze films, and that bronze powder is fused to iron particles.

Example 2

The same bronze powder and iron powder as in Example 1 were used, and 50% of the bronze powder, 49% of the iron powder, and 1% of graphite powder were admixed; the mixture was compacted and sintered in the same manner as in Example 1.

For comparison, a control example 1′ was prepared by compacting a mixture of 98% of an iron powder and 2% of a copper powder and then sintering the compact at a temperature of 1050°C, and a control example 2′ was prepared by compacting a mixture of 90% of a copper powder and 10% of a tin powder and then sintering at a temperature of 800°C. The bearing characteristics of the above four sintered alloys after impregnation with the same lubricant i.e. turbine oil, are shown in Figure 1 of the accompanying drawings. It can be noted that the sintered alloys of this invention have greatly improved bearing characteristics over the conventional Cu-based bearings under a load of higher than 15 kg/mm^2 and a PV value ($kg/cm^2.m/min.$) of higher than 1000, and that the sintered alloys of this invention have better characteristics than the Fe-based bearing alloy over the entire range.

The mechanical strength of the sintered alloys of Examples 1 and 2 of this invention and the control examples 1′ and 2′ was measured. More particularly, the porosity of the compacted and sintered alloys was varied and the compression strength of the alloys was measured and the result is shown in Figure 2, which shows that the sintered alloys of this invention have higher mechanical strength than the control examples at any porosity.

50% of an iron powder having the same particle size as that of the control example 1', 45.5% of a copper powder, and 4.5% of tin were mixed together, and the mixture was compacted under pressure and sintered in the same manner as in Example 1. Figure 4 shows a photomicrograph at a magnification factor of 400. The sintered alloy exhibited the colour inherent to the iron powder and the state of the copper powder was not changed, showing that a eutectic alloy of iron and copper was not formed. This means that the sintered alloy shown in Figure 4 differs substantially from that shown in Figure 3.

Example 3

A brass cast alloy consisting of 60.5% of Cu, 38.5% of Zn, and the balance containing less than 0.5% of each of Pb, Sn, Al, Fe and inherent impurities was melted, and then water atomized into a powder of 60 to 350 mesh. This brass powder was admixed with the same amount of an iron powder of 150—250 mesh and the mixture was compacted into a cylindrical body having an outer diameter of 10 mm, an inner diameter of 4 mm, and a height of 8 mm and the cylindrical body was sintered at a temperature of 850°C in a reducing atmosphere to obtain a bearing.

Example 4

50% of a brass powder, 48% of an iron powder, which were identical to those used in Example 3, and 2% of a graphite powder were mixed together, compacted, and sintered under the same conditions as in Example 3.

A control example 3' comprising a sintered Fe-based alloy was prepared by mixing 90% of an iron powder and 10% of a copper powder, compacting the mixture, and then sintering the compacted body at a temperature of 1050°C, and a control example 4' was prepared by mixing 90% of a copper powder and 10% of a tin powder, compacting the mixture and then sintering the compacted body at a temperature of 800°C. The same lubricant, i.e. turbine oil, was impregnated into the sintered alloys of the control examples 3' and 4' and their bearing characteristics were measured. The results of measurements are shown in Figure 5 which shows that the sintered alloys of this invention have more excellent bearing characteristics than the conventional sintered Cu-based bearing metal under a load higher than 15 kg/mm^2 and a PV value larger than 1000, and that the sintered alloys of this invention show better characteristics than the sintered Fe-based alloy over the entire range of the load.

Figure 6 shows the results of measurement of the mechanical strength of the sintered alloys of Examples 3 and 4 and control examples 3' and 4'. Thus, the porosity of each sintered alloy was adjusted variously and the compression strength of respective samples was measured. Figure 6 shows that the sintered alloys of this invention have higher mechanical strength than the sintered alloys of the control examples regardless of the percentage of porosity.

The following Example illustrates a modification in which a Zn-vapour-containing atmosphere is used instead of simply a reducing atmosphere.

Example 5

A bronze cast alloy consisting of 81.0—87.0% of copper, 4.0—6.0% of Sn, 4.0—7.0% of Zn, and the balance Pb and other impurities was melted and then water atomized into a bronze powder of 100—350 mesh. The bronze powder and an iron powder having a particle size of 150—250 mesh were mixed at an equal ratio, and the mixture was compacted into the form of a bearing member having an outer diameter of 10 mm, an inner diameter of 4 mm, and a length of 8 mm, under a standard pressure of about 2500 kg/cm^2, to obtain a compacted body having a density of about 6.0 g/cm^3. The compacted body was then sintered at a temperature of 850°C in reducing atmosphere.

By way of comparison, an identical mixture containing equal parts of the bronze powder and the iron powder was compacted into the form of a bearing member having the same dimensions as above, under the same compacting pressure of about 2500 kg/cm^2 to have the same density. After disposing Zn on the compacted body, it was sintered at a temperature of 850°C in the same reducing atmosphere. At this sintering temperature the Zn evaporated so that the sintering was performed in a zinc-vapour-containing atmosphere, with the result that about 4% of zinc was absorbed by the sintered alloy. The sintered alloy had a density of 6.2 g/cm^3 and it was found that the mechanical strength (compression strength) of this sintered alloy was higher by 14—15% than the alloy sintered not utilizing the zinc-vapour-containing atmosphere. It was also found that sintered alloys having a relatively low density can achieve a desired mechanical strength. The sintering time was about 30 minutes.

Example 6

In this example, the same bronze powder and iron powder as in Example 5 were used. Thus, 50% of the bronze powder, 49% of the iron powder, and 1% of graphite powder were mixed together and samples of the mixture were compacted under the standard pressure described in Example 5 and under a pressure lower than the standard pressure. The density of the former was 6.0 g/cm^3 while that of the latter was 5.8 g/cm^3. The former was sintered in a reducing atmosphere not containing zinc vapour whereas the latter was sintered in a reducing atmosphere containing zinc vapour as in Example 5. The sintering temperature and time were the same as in Example 5.

Example 7

A brass powder was used as an alloy

consisting mainly of copper. More particularly a brass cast alloy consisting of 60.5% of Cu, 38.5% of Zn, and the balance less than 0.5% each of Pb, Sn, Al, Fe, and unavoidable impurities was melted and water atomized into brass powder having a particle size of 60—350. The powder was mixed with an iron powder having a particle size of 150—250 mesh at equal ratio. Part of the mixture obtained was compacted into the form of a bearing member having an outer diameter of 10 mm, an inner diameter of 4 mm, and a length of 8 mm under a standard compacting pressure of 2500 kg/cm² to obtain a compacted body having a density of about 6.0 g/cm³. Then the body was sintered at a temperature of 850°C in a reducing atmosphere.

On the other hand, another part of the mixture was compacted under a lower compacting pressure, i.e. 2200 kg/cm², to form a compacted body having a density of 5.8 g/cm³. ZnO was heated in a container to form zinc vapour, which was introduced into a sintering chamber in which the compacted body was sintered at a temperature of 850°C for about 30 minutes.

Example 8

The same brass powder and iron powder as in Example 7 were used. Thus, a mixture of 50% of a brass powder, 48% of an iron powder, and 2% of a graphite powder was compacted into a compacted body having the same dimensions as in Example 7 and under the same standard compacting pressure as in Example 7 to obtain a compacted body having a density of 6.0 g/cm³. An identical mixture was also compacted under a lower pressure to obtain a compacted body having a density of 5.8 g/cm³. The former was sintered in a simple reducing atmosphere and the latter was sintered in a zinc-vapour-containing reducing atmosphere in the same manner as in Example 7.

The sintered alloys described in Examples 5 to 8 were impregnated with turbine oil as a lubricant and their bearing characteristics were measured. The results were satisfactory and all samples showed better bearing characteristics than the conventional sintered Cu-based alloys under loads higher than 15 kg/mm² and PV values above 1000. All samples also showed better characteristics than the Fe-based bearing alloys over the entire load range. The temperature rise, mechanical strength (compression strength), and friction coefficient of the samples of the foregoing Examples 5 to 8 compacted at different compacting conditions to have different porosity (volume %) are shown in Figures 7 to 10 in which Figures 7 and 8 show the bronze type sintered alloys of Examples 5 and 6 and Figures 7 and 8 show the brass type sintered alloys of Examples 7 and 8. Thus, Figures 8 and 10 show that bodies compacted under a relatively low pressure so as to have a low porosity have a mechanical strength equal to or higher than that of the bodies compacted under higher pressures. For instance, Figure 8 shows that even when the porosity of the bronze type sintered alloy sintered in zinc-vapour-containing atmosphere is higher than by 3.5—5% that of the bronze type sintered alloy sintered in simple reducing atmosphere, the former has substantially the same compression strength as that of the latter, while Figure 10 shows that the brass type sintered alloy sintered in zinc-vapour-containing atmosphere has substantially the same compression strength even with a porosity higher by 3—4%. The sintered alloys sintered in zinc-vapour-containing atmosphere generally have a tendency of slightly decreasing temperature rise and lowering the friction coefficient. For example, under the same PV value, the temperature rise is less by 1—5°C and the friction coefficient is also decreased, as shown in Figures 7 and 9, meaning an improvement in the characteristics of sintered Cu-based alloys. In Figures 7—10, a sintered alloy sintered in zinc-vapour-containing atmosphere is shown by a black spot, while a sintered alloy sintered in a reducing atmosphere not containing zinc vapour is shown by a white spot.

The above-described Examples 1 to 8 are typical examples of the compositions of the sintered alloys of this invention and it will be clear that many other compositions can be used within the scope of the appended claims. We have mixed an iron powder with various types of Cu-based alloy powders and compacted and sintered the mixture. As the bronzes we used:

1. Cu: 79—83%, Sn: 2.0—4.0%, Zn: 8—12%, Pb: 3—7%.
2. Cu: 86—90%, Sn: 7—9%, Zn: 3—5%, Pb: less than 1%.
3. Cu: 86.5—89.5%, Sn: 9—11%, Zn: 1.0—3.0%, Pb: less than 1%.
4. Cu: 86—90%, Sn: 5.0—7.0%, Zn: 3.0—5.0%, Pb: 1—3%.

As the brasses we used:

5. Cu: 83—88%, Zn: 22—27%, Pb: less than 0.5%, total Sn, Al, and Fe: less than 1%.
6. Cu: 65—70%, Zn: 30—35%, Pb: 0.5—3%, Sn: less than 1%, Al: less than 0.5%, Fe: less than 0.8%.

When compacted and sintered, in all sintered alloys it was found that iron particles were coated with films of Cu-based alloys so that those having the bronze compositions 1 to 4 had the same characteristics as those of Examples 1 and 2 and those having the brass compositions 5 and 6 had the same characteristics as those of Examples 3 and 4.

By suitably changing the ratio of components in the ranges described above, the density of the compacted body, and the sintering temperature, it is possible to manufacture products suitable for such various machine parts as gears, parts of electric motors, valves, etc.

The sintered alloys according to the invention

described above have an excellent fitting property with respect to steel shafts and a corrosion resistance comparable to or more excellent than that of the conventional sintered Cu-based alloys and a mechanical strength comparable to that of the conventional sintered Fe-based alloys. Furthermore, the wear of the metal mould utilized to compact the powders is less than that of the metal mould utilized to compact sintered Fe-based alloys. The sintering in a zinc-containing gaseous atmosphere results in an increase in the mechanical strength of the compacted body even when its density is relatively low; when the powder of the Cu-based alloy contains zinc, loss thereof caused by vaporization can be prevented at the time of sintering. Accordingly, by decreasing the density it is possible to increase the content of the lubricant impregnated into the sintered alloy, thus improving the bearing characteristic.

The term "PV value" used above means the product of load (kg/cm²) and rotating speed (m/min.).

Since the present invention mainly (but not solely) relates to sintered metal bearings, the term "compression strength" used above has a special meaning in the present invention and is equivalent to the technical term "radial crushing strength constant", which is specifically used in the field of powder metallurgy. According to JIS (Japanese Industrial Standards), the "radial crushing strength constant" is determined by the following equation:

$$K=\frac{P(D-T)}{L\cdot T^2}$$

where, K: radial crushing strength constant (kg/mm²)

P: radial crushing strength (kg)
D: outside diameter of bearing (mm)
L: length of bearing (mm)
T: thickness of bearing (mm).

Claims

1. A sintered alloy comprising a mixture of 10 to 85 wt.% of a copper-based alloy powder containing more than 50 wt.% of copper and zinc and/or tin, and 90 to 15 wt.% of an iron powder, the mixture having been compacted and then sintered so that the particles of iron are coated with a copper-rich alloy.

2. A sintered alloy as claimed in claim 1, in which the copper-based alloy powder is a bronze powder containing copper and tin.

3. A sintered alloy as claimed in claim 1, in which the copper-based alloy powder is a bronze powder consisting of 79 to 90 wt.% of copper, 2 to 11 wt.% of tin, and 1 to 12 wt.% zinc, and the sintered alloy further contains solid lubricant in an amount of less than 3 wt.%.

4. A sintered alloy as claimed in claim 1, in which the copper-based alloy powder is a brass powder consisting of 59 to 88 wt.% of copper, less than 1 wt.% (each) of one or more of the metals lead, tin, aluminium, and iron, and the balance zinc, the sintered alloy further containing either 3 to 7 parts by weight of copper powder or 3 to 20 parts by weight of a bronze powder, and either zero to 6 parts by weight of graphite powder or zero to 3 parts by weight of molybdenum powder or molybdenum disulphide powder, respectively based on 100 parts by weight of the mixture of the said brass powder and the said iron powder.

5. A sintered alloy as claimed in any of claims 1 to 5, in which the sintered alloy has been sintered in a zinc-containing atmosphere so that the sintered alloy is impregnated with zinc.

6. A sintered alloy as claimed in claim 5, the sintered alloy having been produced by sintering a compacted body having a porosity of higher than 10% in a zinc-containing atmosphere.

7. A method of manufacturing a sintered alloy comprising the steps of mixing a powder of a copper-based alloy containing more than 50 wt.% of copper and zinc and/or tin with an iron powder at a weight ratio of 10—85% alloy powder to 90—15% iron powder, compacting the resulting mixture, and then sintering the compacted body.

8. A method as claimed in claim 7, in which the sintering is performed at a sintering temperature of 700 to 1000°C in a reducing atmosphere.

9. A method as claimed in claim 7, in which the sintering is performed at a sintering temperature of 700 to 1000°C in a non-oxidizing atmosphere.

10. A method as claimed in claim 8 or 9, in which the atmosphere contains zinc vapour.

11. A method as claimed in claim 7, in which the sintering is performed in an atmosphere containing zinc vapour.

12. A method as claimed in claim 10 or 11, in which the zinc vapour is generated from zinc or zinc oxide disposed on the compacted body.

13. A method as claimed in claim 10 or 11, in which the zinc vapour is generated in a vessel independent of a sintering chamber and then introduced into the sintering chamber, in which the sintering is carried out.

14. A method as claimed in any of claims 7 to 13, in which the copper-based alloy comprises bronze consisting of 79 to 90 wt.% of copper, 2 to 11 wt.% of tin, and 1 to 12 wt.% of zinc.

15. A method as claimed in any of claims 7 to 13, in which copper-based alloy comprises brass consisting of 59 to 88 wt.% of copper, 1 wt.% of one or more of the metals lead, tin, aluminium, and iron, and the balance zinc.

16. A method as claimed in any of claims 7 to 15, in which the said powders are mixed with at least one of the solid lubricants graphite, molybdenum, and molybdenum disulphide.

17. A method as claimed in any of claims 7 to 16, which further comprises impregnating the sintered body with liquid lubricant.

18. A sintered alloy as claimed in claim 1, substantially as described in any of Examples 1 to 8.

19. A method as claimed in claim 7, substantially as described in any of Examples 1 to 8.

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